2nd Annual Symposium
Toward a Global Earth Observation System of Systems
Future National Operational Environmental Satellites

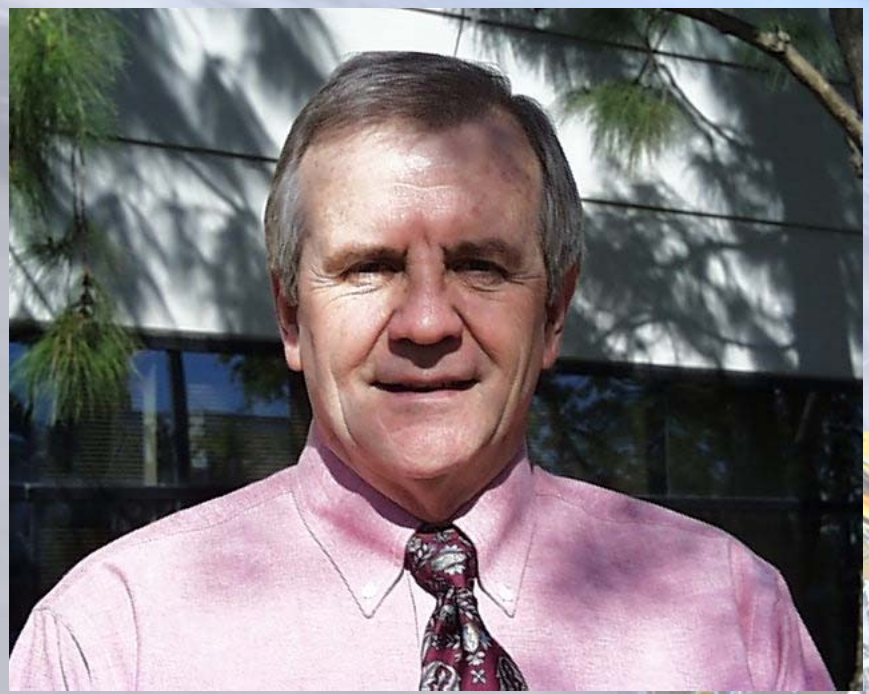
CrIMSS Cal Val Planning and Prelaunch Preparation for NPP and NPOESS

Dr. Arthur W. Dybdahl

Dr. Farhang Sabet-Peyman, Dr. Fwu-Jih Hsu, Dr. Degui Gu
Northrop Grumman Space Technology
Redondo Beach, CA

Dr. Gene. J. Kratz
Raytheon Information Systems,
Landover, MD

CrIMSS CAL/VAL



Arthur W. Dybdahl
Atmospheric Physicist
NGST

- **Deputy to NGST NPOESS Chief Scientist**
- **CrIS Cal Val Sensor Lead**
- **40 Years in Science and Engineering**
- **PhD Physics , 2001**
- **Research in Atmospheric Physics**
  - Trace atmospheric gases in Antarctica affecting the O_3 hole, using absorption FTIR measurements
  - Solar output measurements in 0.97 to 5.13 μm band using radiometrically calibrated FTIR at several ground elevations

Introduction

- **NPOESS – a SSPR Program**
- **CrIMSS Products and Data Chain**
- **NPP Integrated Cal Val Team for CrIS/CrIMSS**
- **NPP/NPOESS draws from Heritage Programs**
- **Prelaunch Sensor Test Data Verification of Performance**
  - CrIS
  - ATMS
- **Prelaunch Verification and Heritage Programs form the Basis for On-Orbit Calibration and Validation**
- **On-Orbit Calibration and Validation Testing**
  - CrIS
  - CrIMSS (CrIS + ATMS)
- **NSIPS and CasaNOSA as Major Utilities for the CrIS/CrIMSS Cal Val Team**

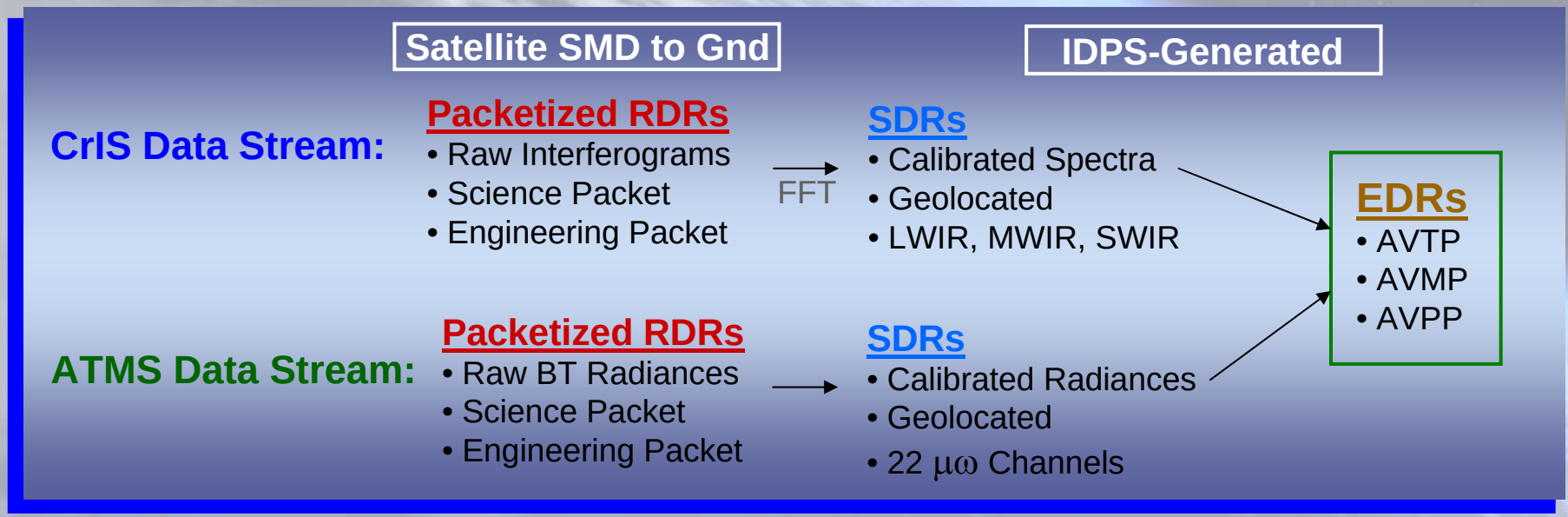
CrIMSS Produces 2 Key EDRs for NPOESS

- **NPP (NPOESS Preparatory Project) is a Risk Reduction Flight**
- **Two of the four NPP Sensors are synergistic at the EDR level**
  - Cross-track Infrared Sounder (CrIS)
  - Advanced Technology Microwave Sounder (ATMS)
- **Forming the Cross-track Infrared and Microwave Sounder Suite (CrIMSS)**
- **CrIMSS is the combination of the CrIS and ATMS output data at SDR products level**
  - CrIMSS EDR Algorithm receives these data as separate SDR Inputs
  - Radiometric/Spectrally calibrated and geolocated
- **CrIMSS EDR Algorithm produces the retrieval of two of the six NPOESS key EDRs**
  - Atmospheric vertical temperature profile (AVTP)
  - Atmospheric vertical moisture profile (AVMP)
- **Additional Atmospheric Products from CrIS/CrIMSS**
  - Derived atmospheric pressure profile (AVPP), from AVTP and AVMP
  - Retrieved IR O3 profiles – supplied as an intermediate product (IP)

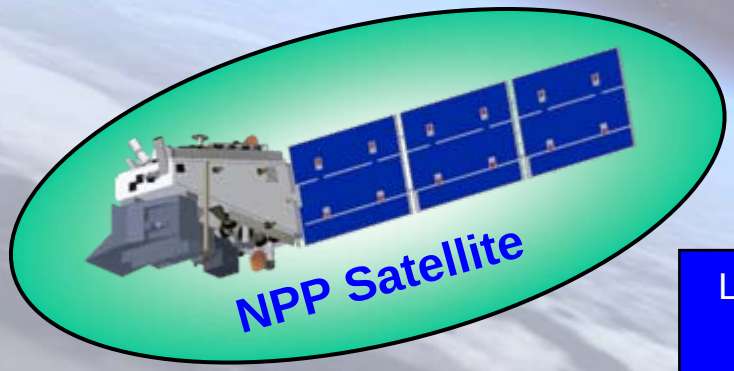
NPP / NPOESS CrIMSS Data Chain

NPOESS Data Product Levels Defined

- RDR = Raw Data Records, Level 0
- SDR = Sensor Data Records, Level 1a and 1b
- EDR = Environmental Data Records, Level 2



Cal Val Process for CrIMSS
NPP → NPOESS C1, C2, C3 . .



Launch

Prelaunch Phase

Ground Testing and Verification

- Extensive Planning / Tools Preparation
- Sensor Performance Verification
  - CrIS EDU3 and FM1 Test Data
  - ATMS PFM Test Data
- RDR Verification
- SDR Verification, Input Parameters
- EDR Verification (Simulation, Matchups)
- Sensor Vendor Support Incorporated
- Data Migrated to NOAA - CasaNOSA

Post-Launch Phase

Early Orbit Activities: L+0 ~ L+1 month

- Spacecraft Activation
  - HRD, LRD and SMD transmitting
  - Attitude Control Calibrations
  - Final Flight Software Updates

Sensor Checkout: L+0.5 ~ L+4 months

- Sensor Activation: CrIS and ATMS
  - CrIS Sensor Outgassing
  - Sensor Functions: Safe, Diagnostic
  - TLM/Housekeeping Data Monitored

Intensive Cal Val: ~L+4 to L+20 months

- Sensor Calibration: Radiance / Spectral
- RDR Performance Validation
- SDR Performance Validation
- SDR Input Parameter Tuning
- EDR Performance Validation

Extended Cal Val: > L+20 months

Integrated SSPR Cal Val Team for CrIS and CrIMSS Validation

- **NGST**
  - Art Dybdahl, CrIS Lead
  - Fwu-Jih Hsu, ATMS Lead
  - Degui Gu, CrIS Algorithm Lead
  - Chunming Wang, Infrastructure
  - Mike Mussetto, NGST Chief Scientist
- **Raytheon – RIS**
  - Gene Kratz, CrIS Support
- **Space Dynamics Lab–USU (IGS)**
  - Gail Bingham, xDR Error Analysis
  - Joe Tansock
- **SSEC, Univ of Wisconsin (IGS)**
  - Hank Revercomb
  - Dave Tobin
  - Bob Knuteson
  - Bill Smith
- **MIT-Lincoln Laboratories (FFRDC)**
  - Bill Blackwell
  - Dan Mooney
  - Dave Staelin (MIT)
  - Phil Rosenkranz (MIT)
- **Univ of Maryland, Baltimore Co (IGS)**
  - Larrabee Strow
  - Howard Motteler
- **NOAA – NESDIS**
  - Changyong Cao
  - Chris Barnet
  - Lihang Zhou
- **NASA – Langley Research Center**
  - Allen Larar (SOAT Chair)
  - Xu Liu
- **NASA - JPL**
  - George Aumann
  - Evan Manning
- **NPOESS Integrated Program Office**
  - Karen St Germain (Cal Val & SE Lead)
  - Elizabeth Ferrara
  - Bruce Guenther (NASA Cal Val Lead)
  - Joe Zajic (CasaNOSA Lead)

Integrating Heritage Cal Val Processes into NPP/NPOESS

NSIPS: Two Parallel Data Streams – Q1 of 2006

- NOAA-18
- EOS AQUA

NPP

Future Launch

METOP

- IASI
- HIRS-4
- AMSU-A and MHS
- Matchup tools ready

Operational

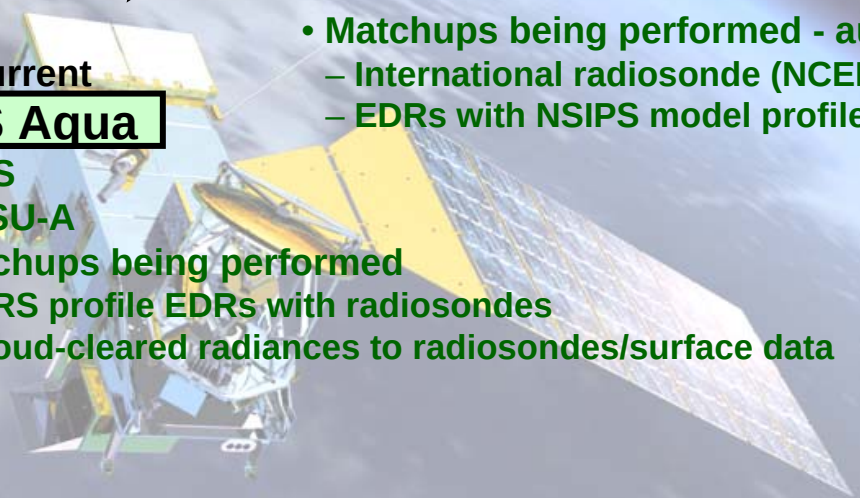
NOAA-18

- HIRS-4
- AMSU-A and MHS
- Matchups being performed - automated
  - International radiosonde (NCEP) daily
  - EDRs with NSIPS model profiles

Current

EOS Aqua

- AIRS
- AMSU-A
- Matchups being performed
  - AIRS profile EDRs with radiosondes
  - Cloud-cleared radiances to radiosondes/surface data



Completed

NOAA-16

- HIRS-3
- AMSU-A/B
- Initial Matchups performed
  - International radiosonde (NCEP) daily
  - EDRs with NSIPS model profiles
  - Fwd model: Simulated SDRs to HIRS-3 measurements

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Prelaunch Verification of Sensor Performance

NPOESS

CrIS Sensor Performance and Calibration Testing – Prelaunch

- **NGST CrIS Cal Val Team participated in Ground Sensor Testing at ITT**
- **CrIS EDU3 Testing – Completed, demonstrated excellent performance**
  - Non-linearity
  - Short-term repeatability
  - Instrument Line Shape (ILS) Characterization: Laser and gas cell (CH4, CO2, HBr)
  - Vibration: Random, shock, sine; Isolation system
  - Performance at bench environment: Pre- and Post-testing
  - Thermal-Vacuum:
    - Mission nominal (MN), ProtoQual High (PQH) and Low (PQL) Temperatures
    - Vibration
    - Dynamic Interaction
    - Radiometric/spectral Characterization, Accuracy, Uncertainty
  - Noise Equivalent Difference in Radiance (NEdN) Performance
    - All Sensor FOVs
    - All IR Bands
    - Temperatures: MN, PQH, PQL
    - Parametric trending
- **CrIS Flight Model 1 (FM1) Testing**
  - Test Readiness Review in Mid-January 2006
  - Follows the EDU3 Protocols closely

Prelaunch Sensor Test Data Verification of Performance

- **Defined and sized Cal Val Tools for CrIS and ATMS**
  - Intermediate Products (IPs)
  - Quality Flags (QFs)
  - Built/Tested Test Data Unwrapper/Reader for both Sensors
  - EDU/PFM Data Analysis Tools
- **Sensor Test Data received, evaluated and migrated to CasaNOSA**
  - CrIS EDU3 Data (completed), FM1 Data coming
    - Bench Performance Verification
    - Thermal Vacuum
    - Vibration
    - Radiance Calibration
    - Spectral Calibration
  - ATMS ProtoFlight Model Data
    - Bench Performance Verification
    - Thermal Vacuum
    - Vibration
    - Radiance Calibration
- **Designed, Build, Performing Proxy Data EDR Matchups**
  - AIRS Radiance Data, NOAA-16 and NOAA-18 Data
  - Planning for IASI Radiance Data
  - Cross Sensor Comparisons

Basis for On-Orbit Sensor Performance Validation

- **Extensive Planning for Post-launch Calibration and Validation**
  - Sensor Checkout Phase
  - Intensive Cal Val Phase
    - CrIS and ATMS RDR and SDR levels
    - CrIMSS EDR level
    - Employ Performance Verification from CrIS EDU3 and FM1 Prelaunch Ground Testing
- **Major Tasks defined and sized for Post-launch Validation**
  - CrIS and ATMS RDRs, SDRs and key joint-sensor EDR Products
    - CrIS SDR Input Parameters for fine tuning and uploading
    - Metadata defined for Cal Val utility
  - Task Duration
  - Estimated Start/Stop dates
  - Priority of each Task: Critical, Important, Nice-to-Have
  - Resources sized for Intensive Cal Val, external to NGST Baseline
  - Participants: NGST, Raytheon-RIS, Sensor Vendors, IPO's IGS/FFRDC Contractors, NOAA-NESDIS, NASA-GSFC, NASA-LaRC, NASA-JPL
  - Exit Criteria for each Task
  - Task Network built and populated for CrIS, ATMS, CrIMSS → CasaNOSA

ATMS Sensor Performance and Calibration Testing – Prelaunch

- **NGST ATMS Cal Val Team participated in Ground Sensor Testing at NGES**
- **ATMS ProtoFlight Model (PFM) Testing - Completed**
  - Non-linearity
  - Short-term repeatability
  - Vibration: Random, shock, sine
  - Performance at bench environment
  - Thermal-Vacuum:
    - Selected Temperatures
    - Radiometric Characterization, Accuracy, Uncertainty
  - Noise Equivalent Difference in Temperature (NEdT) Performance
    - Channel beam patterns
    - 22 Microwave channels
    - Temperatures: Low, nominal, high
- **ATMS Flight Model (FM) Testing**
  - Test Readiness Review in 2006

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On-Orbit Sensor Calibration and Validation

NPOESS

CrIS Sensor Performance and Calibration On-Orbit Testing → SDR

- **CrIS Cal Val Team will participate in all phases of NPP Post-Launch Activities**
  - Initially, the monitoring of Sensor and Spacecraft Telemetry (TLM) for health
  - Intensive Sensor Calibration and Product Validation, though into Extended Cal Val
- **Major RDR/SDR Cal Val Tasks defined, migrated to the CasaNOSA Task Network**
  - **CrIS Sensor Activation and Outgassing**
    - Selected Telemetry trending
    - Health and Status Monitoring / Fault Detection
  - **CrIS RDR Checkout**
    - RDR Parameters using Interferograms
    - RDR Trending using Interferograms
    - Science/Engineering Data Packets
  - **CrIS SDR Checkout**
    - CrIS Thermal Balance Check
    - Correlated/Uncorrelated Noise Characterization
    - Radiometric and Spectral Calibration Evaluation and Parameter Trending
    - SDR Input Parameter Tuning, as necessary
  - **CrIS SDR Baseline**
    - Radiometric and Spectral Calibration Validation
    - Geolocation Validation
  - **CrIS RDR and SDR Error Analysis / Product Quality Assessment**
  - **CrIS Extended Cal Val / Long Term Monitoring (LTM)**
    - Sensor Calibration Assurance
    - SDR Input Parameter Updating

CrIMSS EDR Performance and Product Testing – On-Orbit

- **Major EDR Cal Val Tasks defined, migrated to CasaNOSA Task Network**
  - **CrIS / CrIMSS Radiative Transfer Algorithm (RTA) Checkout and Validation**
    - Performance Validation in conjunction with AIRS, IASI, Aircraft data
    - CrIS SDR Algorithm RTA Validated for EDR Baseline
  - **CrIMSS EDR Validation: AVTP, AVMP, and AVPP (derived)**
    - Over Clear Ocean at Night – Tropical, Mid-latitude, Polar: Nadir and Full-scan
    - Over Clear Ocean at Day – Tropical, Mid-latitude: Nadir and Full-scan
    - Partly Cloudy Ocean at Night – CrIS cloud-cleared ocean scene vs. VIIRS Cloud Mask
    - Cloudy Over Ocean at Night and Day – Nadir and Full-scan
    - Clear Over Land at Night and Day – Nadir and Full-scan
    - Cloudy Over Land at Night and Day – Nadir and Full-scan
    - Cross-sensor validation with AIRS and METOP-IASI
  - **CrIMSS EDR Validation: Matchups with Truth Data**
    - NAST-I, -M under-flight data (as available); CrIMSS and AIRS algorithms adopted for NAST sensors
    - Sea Surface Temperature (SST) measurements
    - Radiosonde observations/measurements
    - Buoy measurements
    - Ship reports
  - **CrIMSS EDR Product Error Assessment**

NAST = NPOESS Airborne Sounder Testbed

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Cal Val Multi-Team Support Utilities

NPOESS Science Investigator Processing System (NSIPS), CasaNOSA at NOAA

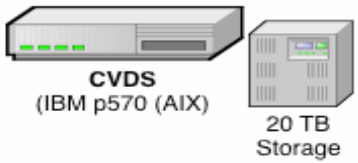
CasaNOSA Task Network: Multi-Team Support Utility

- **SSPR Access to Data, Algorithms, Task Network, Documents, etc.**
  - NPOESS/NPP Science Teams and User Community
- **Algorithm Repository (Gold Standard and Operational)**
  - SDR and EDR
- **Prelaunch Sensor Test Data Repository**
  - CrIS EDU3 (Completed), Flight Model 1, Flight Model 2,etc.
  - ATMS Protoflight Model (Completed), Flight Model
- **System/Sensor Document Repository**
  - System Specs, Test Procedures, etc.
  - CrIS
  - ATMS
- **Cal Val Task Network for Task Tracking – Extended Team**
  - Specific tasks defined, timed and sized
  - Provides task assignments to Team, progress tracking, external resources needed
  - CrIS and ATMS SDR Validation – Post launch
  - CrIMSS EDR Validation – Post launch

NSIPS Overview

What is NSIPS from a Tools perspective?

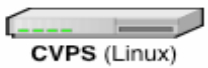
The **NPOESS Science Investigator Processing System (NSIPS)** is a CalVal Database with In-line Science Processing capability that allows for data search and order and subscription services that will allow processing streams to do CalVal tasks such as mission data matchups with truth data and data monitoring and trending. It is made up of four subsystems:



The **CalVal Data Server (CVDS)** is the data server which also does planning and scheduling of science "jobs". Currently there is a 20 TB disk farm for data storage.

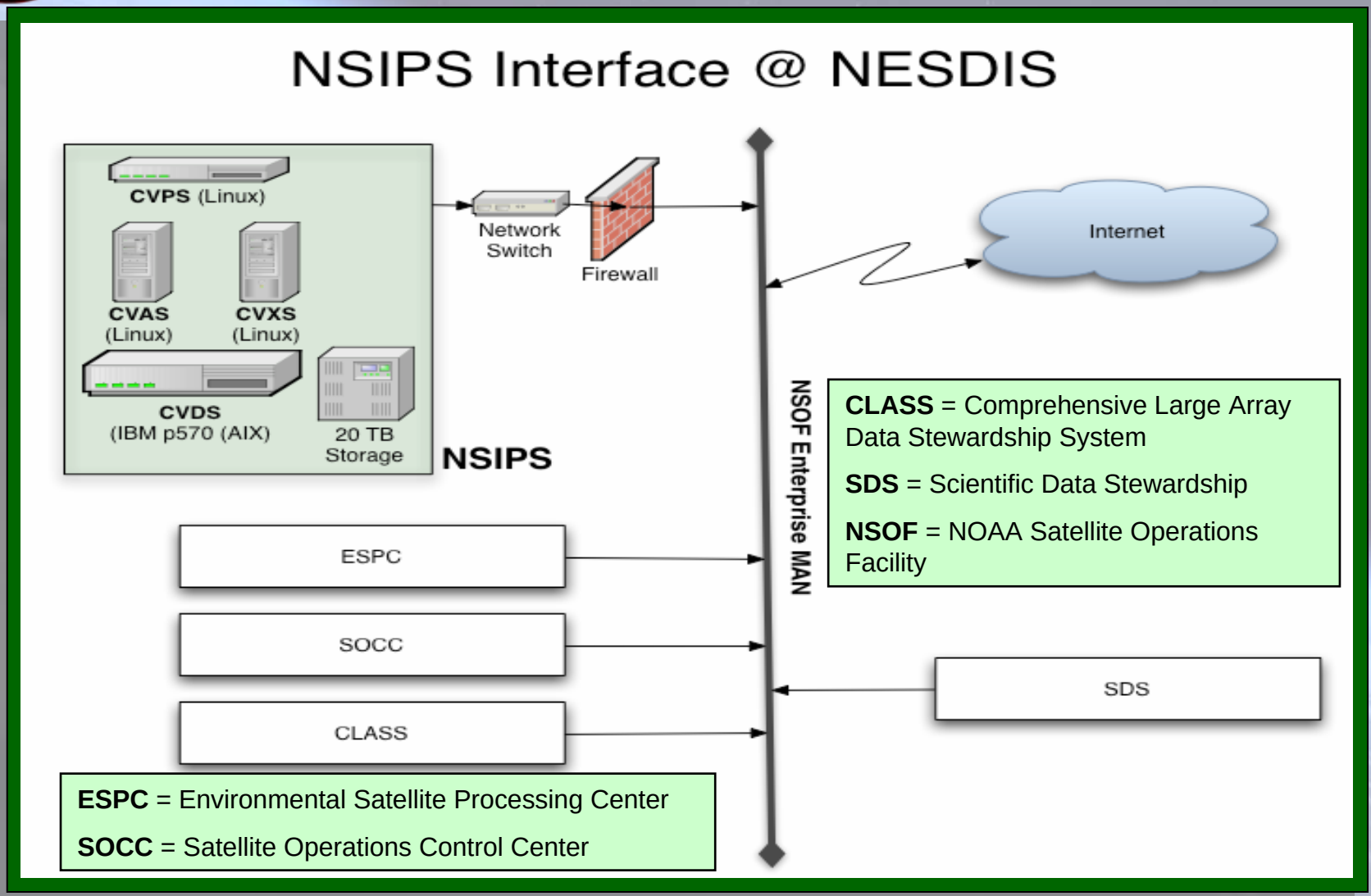
The **CalVal Access Server (CVAS)** is the web interface to the outside world. It has a Search Database and is connected to the CVDS to forward data requests and return status to the users.

The **CalVal eXchange Server (CVXS)** is the ftp server allowing data in and out of NSIPS.

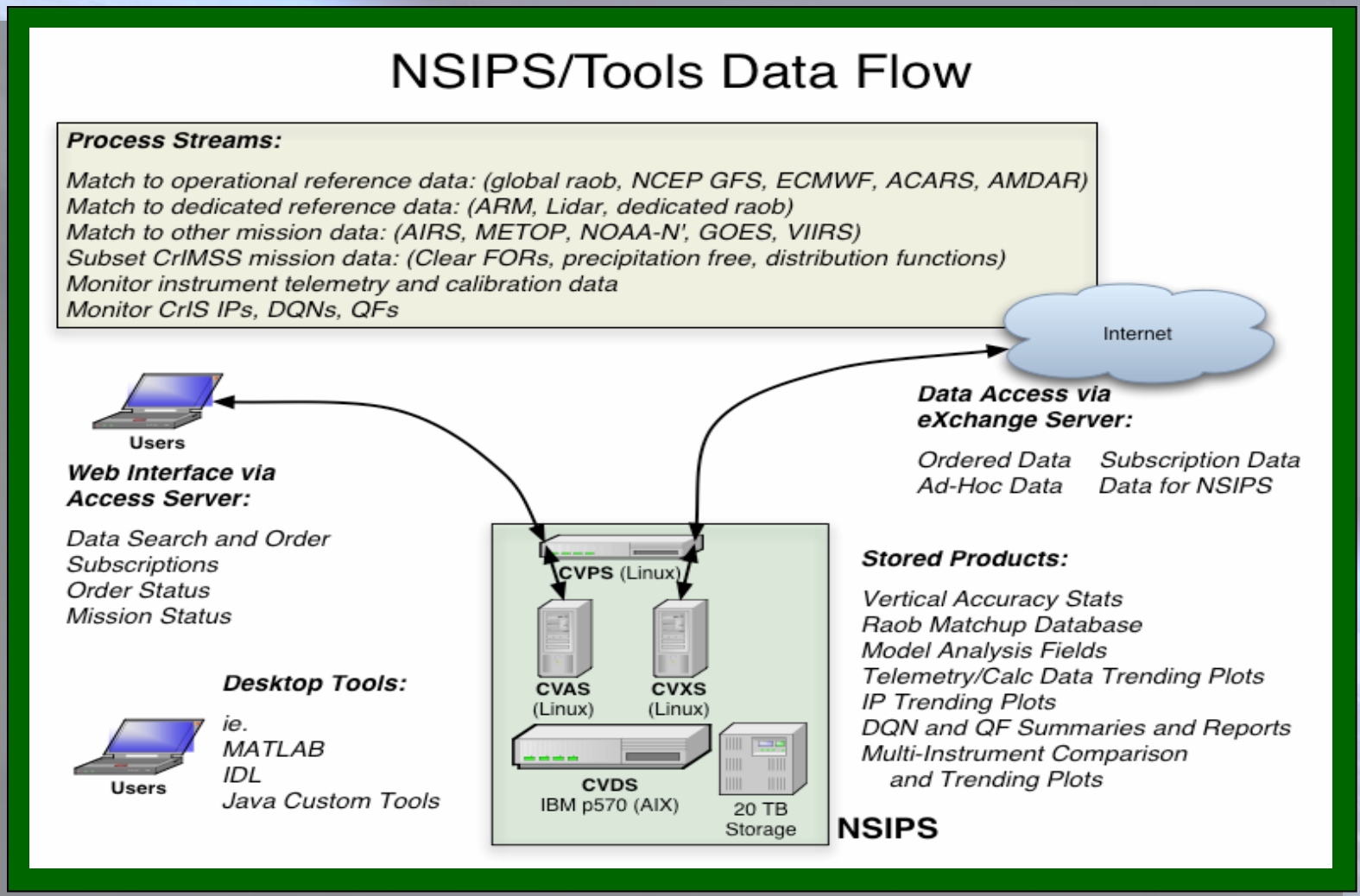


The **CalVal Proxy Server (CVPS)** is the gateway to NSIPS allowing secure ftp and http access using a Username/Password paradigm.

NSIPS Linked with NOAA-NESDIS



CrIMSS Cal Val Uses NSIPS



CrIMSS Radiosonde Matchup Process Flow on NSIPS

Global Raw Radiosonde Data (previous 24 hours) NCEP PRODUCTION server (~2000 per day)

Read NCEP prebuf'r Files & Reformat

QC & Interpolation

Centrals/Extended Cal Val Team Access

Cal Val Team workstations

Processed Raobs Archive

MATLAB, IDL, GIS Analysis (RTM)

CrIMSS EDRs/CrIS/ ATMS SDRs (previous 24 Hours)

Read/extract EDRs, SDRs, and Ancillary data

Radiosonde Matchup

Radiosonde Matchup Archive

Automated Java tools

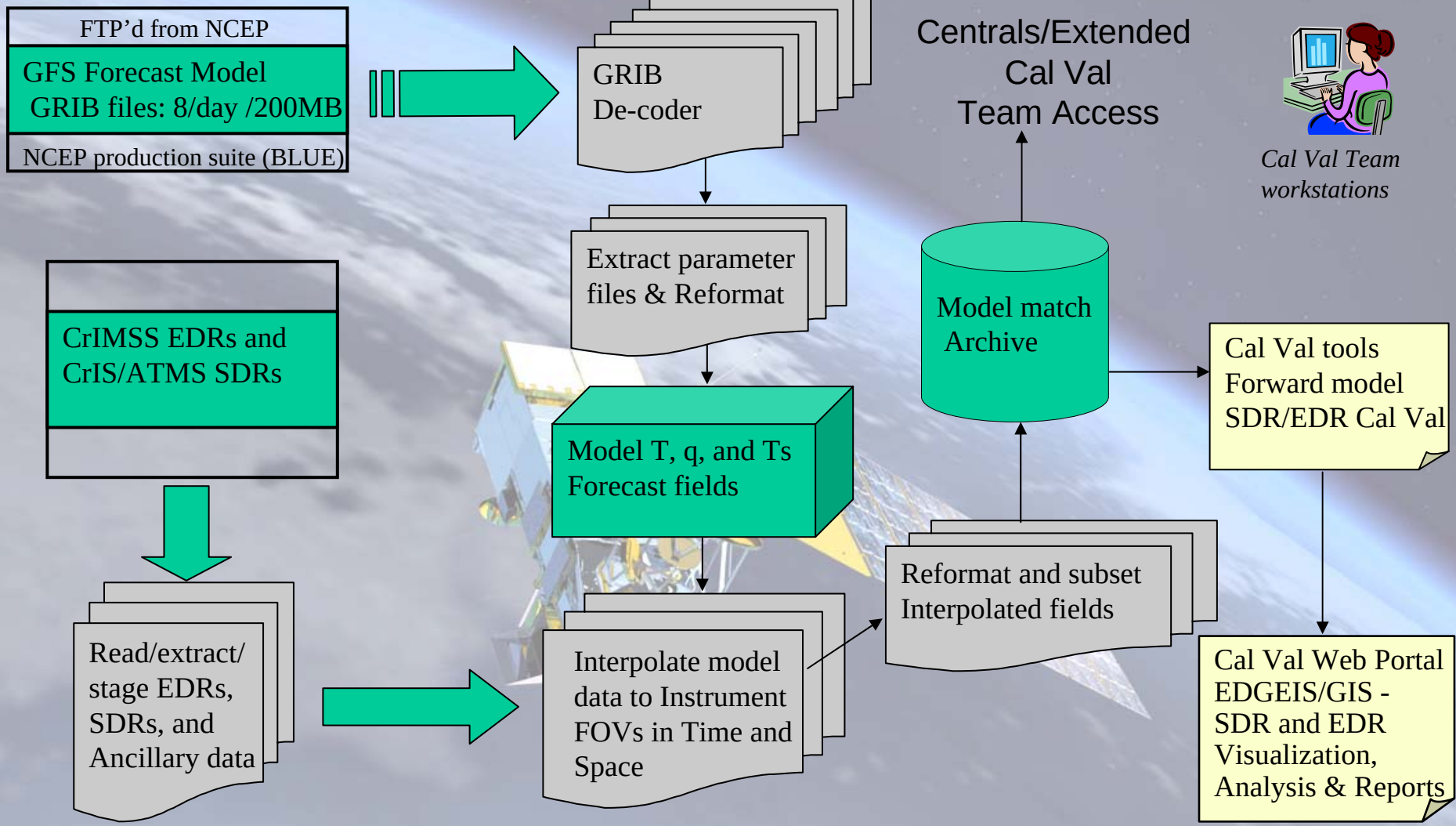
Raob Match File

Matlab Daily Matchfile Monitor

Archive Update

Cal Val Web Portal
- Automated products, plots, analysis, and reports

CrIMSS NCEP GFS Model Matchup Process Flow on NSIPS



CrIS/CrIMSS Cal Val Summary

- **Presented Overview of CrIS, ATMS and CrIMSS Products**
- **Described Cal Val Processes for NPP**
- **Described CrIMSS Data Chain for combining sensor SDRs**
- **Identified the extended Cal Val Team for CrIS, ATMS and CrIMSS**
- **Incorporated Knowledge and Processes from Heritage Programs**
- **Provided Overview of Prelaunch Sensor Performance Verification**
- **Presented On-Orbit Processes for Sensor Calibration and Validation**
  - Sensor RDR and SDR Levels
  - CrIMSS EDR Products: AVTP, AVMP and derived AVPP
- **Briefed the Cal Val Infrastructure that is in place, tested and being used to build and test algorithms/software tools**
- **Cal Val Team will continue to build on, expand and solidify the foundation of the current work to prepare for the Post-Launch Phase of NPP → NPOESS.**

National Polar-orbiting Operational Environmental Satellite System